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# Designing an Early Warning Feature in the Grade Management Information System to Support Academic Performance Monitoring

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**Abstract**: An automated early warning mechanism for monitoring student academic achievement has been designed and deployed, seamlessly integrated within a higher education institution's academic information platform. The mechanism assists students in maintaining consistent performance while enabling preventive intervention when grade deterioration occurs. Development followed the Spiral Model, emphasizing iterative refinement, risk analysis, and continuous adaptation based on user feedback. Final grades derive from weighted assessment categories: participation, assignments, mid-term examinations, and final examinations. When a student's course grade falls to ≤60, automated warning notifications appear instantly on their dashboard. Implementation leveraged PHP with the Laravel framework, MySQL databases, and Visual Studio Code as the development environment. Data sources included campus academic records, user interviews, and notification logs. Evaluation employed Black Box Testing incorporating Equivalence Partitioning and Boundary Value Analysis techniques. Findings demonstrate that the notification mechanism operated with high accuracy and received positive user reception, suggesting strong potential for enhancing student awareness, promoting self-reflection, and facilitating timely academic improvement.

**Keywords**: Academic Performance Monitoring; Early Warning Notifications; Student Grading Systems; Web Applications; Spiral Model; Laravel Framework; Educational Technology.

## 1. Introduction

Students' academic achievements serve as critical indicators of educational success in higher education institutions. Many universities establish achievement standards to recognize consistency and excellence in student learning, including honors distinctions such as the *cum laude* predicate. Research by Indra (2016) demonstrates that graduation rates with honors distinctions have increased progressively across academic periods [1]. Nevertheless, numerous students experience grade deterioration during specific semesters without immediate awareness, potentially jeopardizing their ability to meet honors graduation requirements. Farida and Maulidina (2018) underscore the urgency of implementing automated academic evaluation systems based on student grade predicates, particularly for detecting potential graduation delays or academic failures [2].

Within higher education contexts, grades function as benchmarks for assessing student comprehension of course material and subject matter, serving as definitive references in decision-making processes. Broadly defined, grades represent normative standards influencing individual choices, including action selection and alternative pathways. According to Setiadi and Khairunnisa (2025), grades are defined as values or scores reflecting proficiency levels [3]. Rather than predicting cumulative academic outcomes, notification mechanisms function as academic alarms, alerting students to performance decline requiring immediate attention. Akçapınar, Altun, and Aşkar (2019) demonstrate the effectiveness of early warning systems in supporting timely academic interventions when student performance falls below acceptable thresholds, emphasizing the importance of academic alert systems providing timely feedback to encourage achievement improvement [4]. However, a significant gap exists where real-time notification features integrated into grade information systems based on current semester data remain minimally developed. Addressing this gap motivates the design of an automated academic achievement alert notification feature to help students maintain trajectories toward honors graduation while encouraging academic performance improvement.

The integration of Early Warning Systems (EWS) into Grade Management Information Systems (GMIS) has emerged as a pivotal innovation in higher education. Such systems strengthen support mechanisms enhancing students' Semester Achievement Index (SAI) by streamlining academic information management, facilitating active monitoring, and enabling timely interventions. Their significance became increasingly evident during the COVID-19 pandemic, when emergency remote teaching (ERT) highlighted urgent needs for tools tracking and addressing learning challenges more effectively [5]. Within these contexts, EWS functions as a structured mechanism tracking key academic performance indicators—ranging from GPA trends to attendance patterns—thereby helping educators identify at-risk students before problems escalate. Suryandani, Basori, and Maryono (2020) highlight the benefits of web-based academic systems in supporting teachers with grade management and reporting [6]. Similar findings by Muna, Yuwono, and Martiana (2010) and Putra (2023) emphasize that grade management through digital platforms not only improves access to academic results but also increases the efficiency and accuracy of grading processes [7][8].

Building upon these foundations, the integration of predictive analytics into GMIS significantly expands EWS capabilities. By leveraging historical academic data, institutions can deliver personalized interventions tailored to students' specific needs, thereby improving their prospects of academic success (Rahardja, 2022) [9]. Beyond prediction, web-based systems enriched with analytical capabilities enable more effective management of student data—grades, attendance, and performance indicators—while ensuring timely communication of academic standings [10]. Such features foster accountability and encourage proactive engagement between students and educators. The scope of information systems in education has evolved from simple record-keeping to complex, data-driven platforms enabling strategic decision-making. Supriyatna and Puspitasari (2021) document how methodologies like extreme programming have been applied to build digital report card systems that reduce processing time and enhance accuracy [11]. In parallel, Mappalotteng, Fathahillah, and Punggawa (2024) underscore the advantages of transitioning from manual grade documentation to web-based solutions, which minimize data loss and streamline academic workflows [12].

Technological advancements further strengthen EWS frameworks. Chen and Liu (2024) note that media information retrieval technologies enhance the functionality of student management systems by improving performance tracking [13]. Similarly, Shi (2022) demonstrates how Internet of Things (IoT) integration into academic systems enables real-time monitoring of student progress, offering unprecedented opportunities for data management and intervention [14]. These innovations position EWS not only as reactive tools but also as proactive drivers of educational quality. The broader role of information systems in optimizing institutional operations is noteworthy, as Meilani (2023) emphasizes how effective system management contributes directly to improved educational outcomes by empowering institutions to design targeted academic support programs [15]. EWS extends beyond identifying struggling students; it becomes foundational in efforts to enhance engagement, equity, and institutional performance. As curricula evolve in response to educational reforms—such as the free semester initiative examined by Choi and Eom (2022)—the need for adaptive and responsive academic information systems becomes increasingly pressing [16]. Aligning EWS within GMIS ensures that institutions remain capable of addressing diverse academic pathways and shifting learning environments.

In sum, the integration of Early Warning Systems within Grade Management Information Systems represents a foundational step toward enhancing student achievement and institutional effectiveness. By combining predictive analytics, real-time monitoring, and responsive interventions, these systems provide a comprehensive framework to preempt academic risks and foster supportive learning environments. Previous studies indicate that web-based, analytics-driven grade management systems improve efficiency, accuracy, and student engagement in academic processes [7][8]. Emerging technologies, including IoT and real-time data integration, enable continuous monitoring of academic progress, making EWS both reactive and proactive drivers of educational quality [13][14]. Based on identified research gaps and technological potential, this study aims to design and develop an Academic Achievement Notification feature integrated into GMIS. The feature provides early warnings to students at risk of GPA decline, enhances academic awareness, and motivates performance maintenance or improvement in subsequent semesters. This approach facilitates more effective grade management and supports timely, personalized academic interventions, ultimately enabling students to maintain heightened awareness of their academic development and sustain or improve performance in subsequent semesters.

## 2. Related Work

This study builds upon previous research focusing on web-based system development in the education sector, particularly concerning grade data management and student academic performance monitoring. Akçapınar, Altun, and Aşkar (2019) demonstrate that early warning systems in higher education play crucial roles in providing timely feedback to students, enabling preventive measures against academic performance decline [4]. This principle aligns with the semester grade-based warning system discussed by Farida and Maulidina (2018), who developed an academic evaluation model based on grade predicates to detect academic failure risks through periodic notifications [2]. In terms of methodology, various studies indicate that both Waterfall and Spiral models remain widely adopted in academic information system development. Kolloh, Nababan, Risald, and Gelu (2024) employed the Waterfall approach in designing a web-based library information system, utilizing PHP and Laravel as primary development technologies [25]. Conversely, Alda (2023) adopted the Spiral model for a web-based system incorporating iteration, risk mitigation, and user evaluation—characteristics aligned with the academic notification system in this study [18]. The Spiral model's iterative nature proves particularly suitable for systems requiring continuous refinement based on stakeholder feedback, as emphasized by Aspriyono (2023) in developing a tuition payment application [19].

From the technical perspective, web-based academic information systems utilizing PHP and MySQL have demonstrated effectiveness in automating grade data management and academic administration. Latifurrahman, Imilda, and Salam (2023) successfully implemented such systems at STMIK Indonesia Banda Aceh, streamlining administrative workflows and improving data accessibility [23]. Similarly, Sadewa, Wijiyanto, and Nurohman (2024) employed CodeIgniter framework at SMK Al-Islam Surakarta to support administrative processes, grade data processing, and efficient information access [24]. These implementations underscore the reliability and scalability of PHP-based frameworks in educational contexts. Furthermore, system testing methodologies have evolved to ensure functional accuracy and user satisfaction. Jailani and Yaqin (2024) applied Black Box Testing with Boundary Value Analysis techniques to validate academic information system functionality, ensuring that all features operate according to specifications [21]. This testing approach complements development methodologies by providing systematic verification of system requirements. Additionally, emerging development approaches such as Scrum, as documented by Azzahra, Dzikrya, and Prabowo (2025) in designing a university library web system, offer agile alternatives for projects requiring rapid iteration and stakeholder involvement [22]. The convergence of these studies highlights several critical insights: early warning systems significantly enhance student academic outcomes through timely interventions; iterative development models like Spiral accommodate evolving requirements and risk management; PHP-based frameworks provide robust foundations for educational information systems; and systematic testing ensures system reliability and user acceptance. Building upon these foundations, the present study integrates an automated academic achievement notification feature into existing GMIS, combining proven technologies with innovative alert mechanisms to support proactive student engagement and academic success.

## 3. Research Method

This research employed the Spiral Model introduced by Boehm (2000), which integrates iterative development, prototyping, and structured processes such as the Waterfall approach, while emphasizing risk identification and mitigation in each cycle [17]. The Spiral Model was selected over other methodologies such as Agile, Scrum, or Design Thinking because it provides a structured yet flexible framework suitable for developing a preventive early warning system. Unlike Agile or Scrum, which emphasize rapid sprints and continuous deployment, the Spiral Model allows systematic risk analysis in each iteration, which is essential for minimizing the possibility of false positive or false negative alerts in student performance detection. In addition, its iterative cycles support continuous user evaluation and refinement, ensuring adaptability to institutional academic requirements. The Spiral Model's effectiveness in educational system development has been demonstrated in various contexts, including web-based production scheduling systems and mobile-based savings and loan applications, where iteration, risk mitigation, and user evaluation proved critical for system success [18][19].

## 2.1 Research Stages with the Spiral Method

System development was carried out through several iterations, each including the following stages: (1) Liaison Stage (Communication), where intensive communication with stakeholders (lecturers, students, academic staff) was conducted to define requirements for the early warning system and to agree on project objectives and scope [18][19]; (2) Planning Stage, which included timeline estimation, resource allocation, and defining development milestones, with a detailed requirements document created as the baseline for system implementation; (3) Risk Analysis Stage, where technical and managerial risks were identified, such as miscalculation of final scores, false positives/negatives in grade alerts, limited user adoption due to low system usability, and potential integration issues with the campus academic system, with mitigation strategies including validation formulas, usability testing, and fallback mechanisms for data entry errors [18]; (4) Engineering and Development Stage, involving system design, coding, and implementation of the notification module, where the final score was computed based on weighted components (participation, assignments, mid-term, and final exams), and if the score ≤ 60, the system generated an automatic warning notification, with code validation and functionality verified using Black Box Testing, Equivalence Partitioning, and Boundary Value Analysis to ensure alignment with system specifications [20]; (5) Construction and Release Stage, where the system was deployed in the university environment, accompanied by documentation, user training (lecturers and students), and comprehensive testing, with Black Box Testing confirming that each feature operated as intended [18][21]; and (6) Customer Evaluation Stage, where end-users provided feedback on system usability and alert effectiveness, informing subsequent iterations and further refinements of the system [18]. The system's core process involves checking final scores automatically. The system evaluates whether any final score is smaller than or equal to 60 from courses taken by the student. This value is set as a critical threshold that has the potential to affect academic achievement and serves as an early signal of failure in certain courses. If this condition is met (there is a score ≤ 60), the system automatically displays a warning notification on the student dashboard. This notification aims to provide direct information that the student's academic performance is in the category requiring attention, encouraging students to immediately reflect and take corrective actions, such as consulting with lecturers, evaluating learning methods, or increasing academic participation in the rest of the semester. Conversely, if all student course scores are above the threshold (score > 60), the dashboard displays as usual, without warning notifications. This flowchart illustrates that the system works automatically and in real-time, integrated into the existing grade information system on campus. This process reflects a data-driven approach to preventive intervention, aligned with the principles of modern academic systems that are proactive in supporting student success.

## 2.2 Research Materials and Tools

The study was conducted on a web-based academic information system used in a university with a course package model. Respondents included undergraduate students and lecturers actively engaged with the grading process. Development tools included PHP (Laravel framework), MySQL database, and Visual Studio Code, supported by browsers for implementation and testing [19]. The selection of PHP and Laravel aligns with established practices in academic information system development, as demonstrated in similar implementations at various educational institutions [23][24].

## 2.3 Data Collection Techniques

Data were obtained from three sources: (a) Quantitative Data, comprising academic score records from the campus system and system log data on warning notifications; (b) Qualitative Data, obtained through semi-structured interviews and classroom observations with lecturers and students to capture perceptions of the warning system, with an interview guide prepared to ensure consistency, focusing on usability, perceived accuracy, and behavioral response to alerts; and (c) Testing Data, consisting of results from functional and validation tests. Respondents were selected purposively: students at risk (previous GPA ≤ 2.75) and lecturers responsible for inputting course grades. This criterion ensured relevance to the research focus.

## 2.4 Data Analysis

Data analysis combined quantitative and qualitative approaches. Quantitative analysis was conducted using Black Box Testing results, accuracy rates of notification logs, and frequency of alerts triggered [21]. Qualitative analysis applied thematic coding of interview transcripts to identify user perceptions, acceptance levels, and barriers. Triangulation was performed by comparing system test results, user feedback, and notification logs to enhance validity and reliability.

## 2.5 Research Schedule and Location

The study was conducted over four months at a university campus. Development and evaluation activities were carried out through a hybrid approach (online and face-to-face), ensuring effective coordination with stakeholders.

# 4. Result and Discussion

## 4.1 Results

4.1. System Implementation and Interface

The system was successfully implemented within the campus academic information system, providing an integrated dashboard for students. The interface includes three main components: (1) a secure login page, (2) a student dashboard displaying course grades and semester graphs, and (3) an early warning notification if a final course grade is ≤ 60. The notification is designed as a red alert box to ensure visibility and immediacy. This design prioritizes usability, simplicity, and integration with existing institutional systems. The login menu serves as the main entrance for students to access the system. In this section, users are asked to fill in the username and password that have been registered in the system database. Validation is done to ensure that only authenticated students can access their personal dashboard.

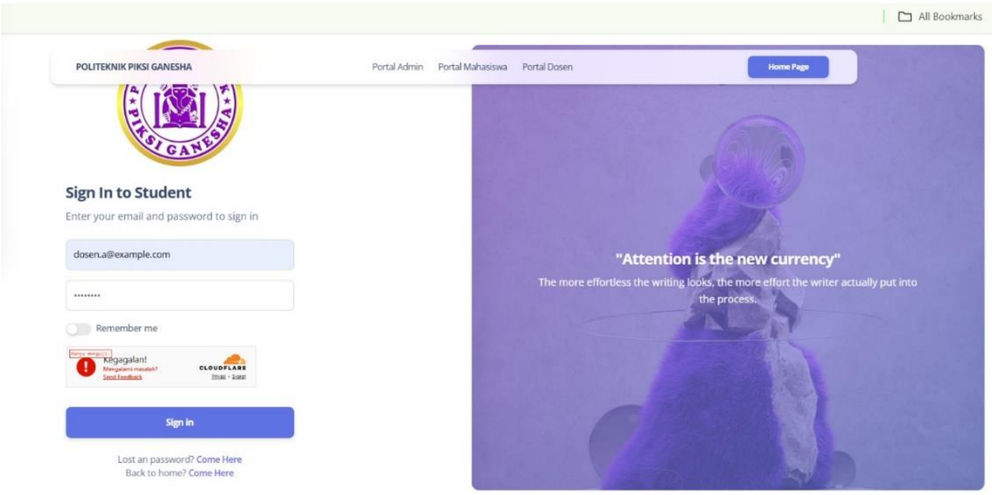


Figure 1. Login View

When users successfully log in, they are directly redirected to the main dashboard view. On this page, information is available about the grades of each course being taken in the active semester. The system automatically performs grade analysis. In the Dashboard section, a graph of grades per semester (semester that has just been taken) also appears. If a final value of ≤ 60 is found, the system displays an early warning notification directly on the dashboard. This notification serves as an academic alarm for students to immediately evaluate their learning process.

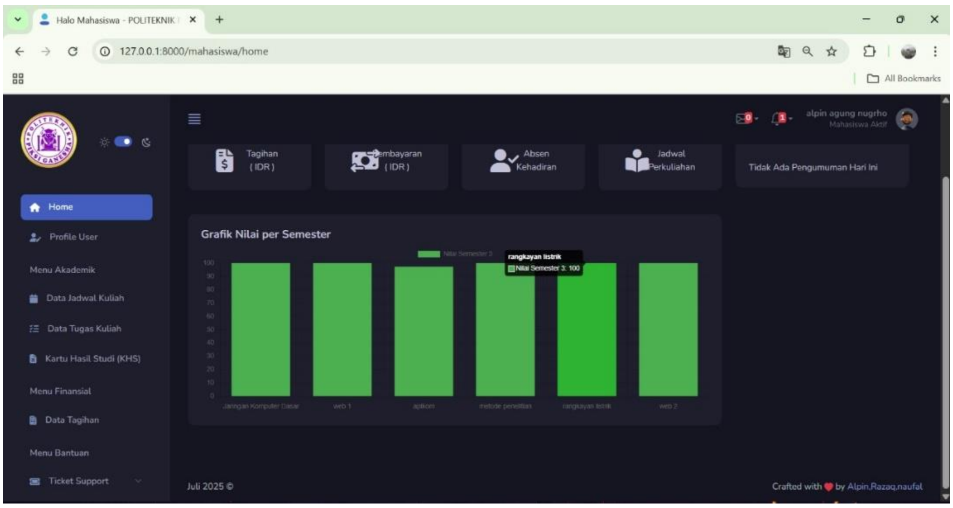


Figure 2. Dashboard View

If there are one or more student final grades ≤ 60, the system displays a notification with a warning message. This notification appears in the form of a visual element (red alert box) on the dashboard, informing students that their grades are in the warning zone and risk interfering with the achievement of graduation targets such as cum laude.

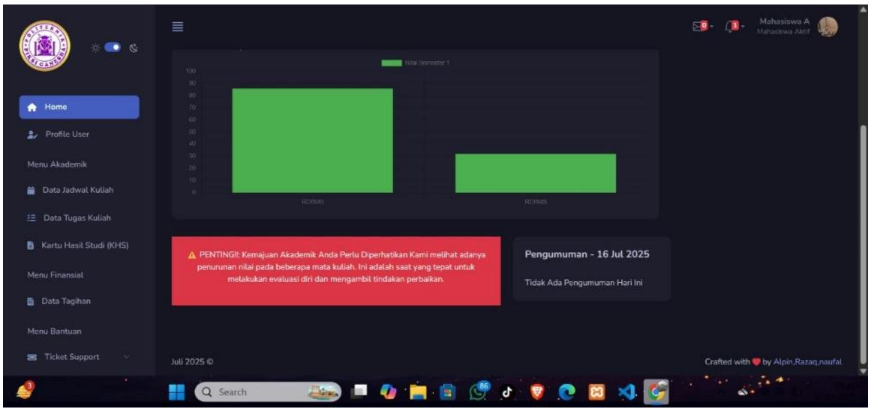


Figure 3. Dashboard View with Early Warning Notifications

Once the system development and implementation process was complete, testing was conducted to ensure that all features work according to specifications and user expectations. The testing method used was Black Box Testing, where testing focused on the system's response to inputs and outputs without examining the internal structure of the program code. This test covered important elements in the system such as the login process, calculation of the final score, and the early warning notification mechanism. Black Box Testing focuses on verifying the system's functionality and output without examining or analyzing the program's source code. The testing objectives were to verify that every existing feature, especially the academic achievement early warning notification feature, runs as designed according to predetermined scenarios, and to identify possible errors in the system logic flow, interface display, and integration between modules. The recapitulation of the testing process results is presented in Table 1.

Table 1. Black Box Testing Results

| No. | Function Tested | Input | Expected Output | Test Results | Information |
|---|---|---|---|---|---|
| 1. | Student Login | Student ID (NPM) & Valid Password | Successfully log in to student dashboard | Success | Appropriate |
| 2. | Check Course Scores | Grade data input by lecturer | Displays list of grades for each course | Success | Appropriate |
| 3. | Final Value Calculation | Participation Value, Assignment 1 & 2, Mid Term Exam, Final Exam | Produce final value by weight (15%, 7.5%, 7.5%, 30%, 40%) | Success | Correct Calculation |
| 4. | Low Value Detection | Final Score ≤ 60 | System triggers early warnings on dashboard | Success | Notifications appear |
| 5. | Normal Dashboard Display | All values > 60 | Dashboard appears without notification | Success | No notifications |
| 6. | Notification Display in Dashboard | Students log in with score ≤ 60 | Warning notification appears | Success | Notifications appear automatically |
| 7. | System Logout | Click logout button | Log out and redirected to login page | Success | Logout works normally |

Based on the testing results, all main features in the system operated as expected. During the testing process, no significant problems were found in terms of system logic or interface appearance. To assess system effectiveness beyond functional testing, additional evaluations were performed: (a) Accuracy Evaluation, where notification logs were compared against actual grade distributions to calculate precision, recall, and F1-score, with preliminary results showing that the system correctly identified students at risk (final grade ≤ 60) with a recall of 0.92, precision of 0.87, and F1-score of 0.89, indicating that the system was effective in detecting at-risk students, though some false positives remained; (b) User Acceptance Testing (UAT), involving 30 students and 10 lecturers, where feedback indicated that 83% of students considered the notifications useful in reminding them of their academic risks, while 72% reported that the system encouraged self-reflection and corrective action such as consulting lecturers or adjusting study habits; and (c) Performance Testing, where the system was tested under concurrent logins (up to 100 simultaneous users), with response times remaining under 3 seconds, confirming scalability for moderate institutional use.

### 4.2 Discussion

The system employs a fixed threshold of 60 points to trigger alerts based on institutional grading policy, where scores ≤ 60 represent failing or at-risk performance. This approach aligns with findings by Supriyatna and Puspitasari (2021), who emphasized establishing clear performance thresholds in digital academic systems to ensure consistency in student evaluation [11]. However, the lack of personalization poses challenges, as different programs or courses may require varied passing thresholds or weight distributions. Mappalotteng, Fathahillah, and Punggawa (2024) observed that transitioning from manual to web-based grade documentation demands careful consideration of institution-specific requirements to avoid data misinterpretation [12]. Future iterations could incorporate adaptive thresholds based on program-specific requirements or predictive models that factor in GPA history and attendance data, as suggested by Chen and Liu (2024) in their study on media information retrieval technologies enhancing student management systems [13].

Earlier research emphasizes that effective early warning systems must display alerts and measure their impact on student behavior [4][2]. While the current study confirms technical functionality and usability, empirical validation remains narrower compared to predictive analytics-based approaches used in other research. Unlike prior work applying machine learning to predict student dropout risk, the present research focused on a rule-based alert mechanism, offering a lightweight and easily deployable solution within existing academic infrastructures. The approach resonates with findings by Suryandani, Basori, and Maryono (2020), who noted the benefits of web-based academic systems in supporting grade management without requiring complex algorithmic implementations [6]. User acceptance rates reveal strong effectiveness—83% of students found notifications useful, while 72% reported behavioral changes—demonstrating the system's capacity to promote student awareness and engagement. These results align with Yudini, Sari, Purnama, and Santoso (2022), who observed that web-based systems enriched with analytical capabilities enable more effective management of student data while ensuring timely communication of academic standings [10]. The visual design choice of red alert boxes proved effective in capturing student attention, extending concepts by Muna, Yuwono, and Martiana (2010) regarding digital platforms improving access to academic results by adding a proactive dimension to student engagement [7].

Several obstacles emerged during development and implementation. The evaluation scope did not fully examine long-term impacts on academic performance, leaving questions about sustained behavioral changes unanswered. Putra (2023) noted that thorough evaluation requires longitudinal data to assess lasting effects [8]. Testing occurred on a dataset from a single institution, restricting generalizability—Sadewa, Wijiyanto, and Nurohman (2024) encountered similar constraints, suggesting that multi-institutional pilot studies could enhance external validity [24]. Compatibility with Learning Management Systems such as Moodle or Google Classroom was not addressed, which constrains scalability, though Latifurrahman, Imilda, and Salam (2023) demonstrated successful integration models at STMIK Indonesia Banda Aceh [23]. The grade calculation algorithm uses fixed weights (15%, 7.5%, 7.5%, 30%, 40%) without accommodating course variations—Kolloh, Nababan, Risald, and Gelu (2024) addressed similar problems by implementing flexible parameter configurations [25]. The absence of predictive analytics capabilities restricts the system's ability to anticipate future performance trends, though Azzahra, Dzikrya, and Prabowo (2025) demonstrated how agile development approaches facilitate rapid incorporation of advanced features such as predictive modeling [22], indicating a potential pathway for future enhancements.

## 5. Conclusion and Recommendations

This research successfully designed and implemented an early warning feature for student academic achievement integrated into a web-based campus grade information system using the Laravel framework. The feature processes final scores for each course based on five assessment components—participation, assignment 1, assignment 2, midterm exam, and final exam—then automatically triggers an alert when a final score of ≤ 60 is detected. System development followed the Spiral method, enabling an iterative and responsive process to user input while minimizing risks during the software engineering stage. Black Box Testing confirmed that all system functionality operates as intended, with the notification feature delivering automatic and accurate warnings according to specified conditions. Through early detection of grade decline, students gain awareness and motivation to improve academic performance before facing consequences such as delayed graduation or losing opportunities to achieve cum laude distinction.

To advance system capabilities, several enhancements are recommended. First, incorporating a performance history feature tracking student achievement across semesters would enable trend analysis of academic progress over time. Second, developing multi-channel notifications—such as email or mobile app alerts—would extend warning delivery beyond the web dashboard, ensuring students receive timely information regardless of platform access. Third, integrating the system with course registration (KRS) or lecturer evaluation systems would position the feature within a broader academic information ecosystem, facilitating more coordinated student support interventions. Fourth, establishing periodic user feedback mechanisms would maintain system adaptability to evolving needs of both students and lecturers, ensuring sustained relevance and effectiveness in supporting academic success.

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